EMPIRICAL MODEL DEVELOPED FOR DUYVIS COCOA LIQUOR PRESS PERFORMANCE EFFECTIVENESS DETERMINATION AND CONTROL

Felicia O. Akerele[1] , Leo. A. S. Agbetoyeand Basil O. Akinnuli[1] and

[1]Federal Polytechnic, Ado Ekiti, Nigeria.

Department of Agricultural and Bio-Environmental Engineering

[2]Federal University of Technology, Akure, Nigeria.

Department of Agricultural and Bio-Environmental Engineering

[2]Federal University of Technology, Akure, Nigeria.

Department of Mechanical Engineering

Email :[1]felakerele@gmail.com[2]lasagbetoye@yahoo.com and[1]ifembola@yahoo.com

GSM:+ 2348035807570 [1], + 234 08038040355, [3+]234803465595222

ABSTRACT: Empirical model was developed which was used to determine the effectiveness of cocoa liquor press (Duyvis as case study) in cocoa processing industries. The three major strategic decisions considered are: machine availability, performance efficiency and rate of quality of product. Used attributes to these strategic decisions were, for availability: running time per day and operating running time per day. That of machine efficiency are: machine net operating rate and it's operating speed rate while for machine rate of quality product: quality of output per day, throughput per day and running time per day of the machine were considered. Validation of this model prescribed the machine's strategic decisions thus: availability 96 %, efficiency 88 %, and quality rate 99.5 %. Product of these strategic decisions revealed that the machine, Duyvis press is 84 % effective which is below the recommended standard of≥ 85 % effectiveness. Conclusively, one of the strategic decisions "efficiency" is below the recommended standard and need to be improved in order to meet the set standard overall machine effectiveness. This can be achieved by improving both the attributes that determined the machine efficiency which are: machine net operating rate and its operating speed rate.

KEYWORDS: Empirical model, DUYVIS, Cocoa Liquor,Performance determination, Effectiveness and Control, Model Validation

Introduction

Cocoa is a common ingredient for various food and confectionery products. Industrial processing of this ingredient however is normally not optimized due to failure of application of appropriate analytical tools. Furthermore, cocoa processing is normally operated in semi-continuous mode, and this adds to the difficulty in optimizing the various unit operations involved.

ISSN 2229-5518

This study was motivated by the recent emergence of demand for machine effectiveness to increase productivity of industries in our society into which our agricultural industry must integrate. Computer can be used to assist agricultural decision-making through such tools and techniques as optimization, simulation,fuzzy logic,expert systems, and computer aided drafting (CAD).

Effective optimization model development is essential for agricultural equipment. This enhances the repair and maintenance of equipment at the most appropriate time. It is being used in the developed world to know the salvage life of the machine, when you need to change the machine, the time to carry out certain periodic maintenance and repair. This also helps in determining the degree of utility of the equipment (Harrington, 1998).

The determination of capacity utilization which leads to performance evaluation compels the users of the agriculture equipment/machinery to adopt the model. Simulations can be used to model farm and machine events overtime to predict what would happen when particular machinery sets were chosen. Important factors include types of equipment and operations that are to be considered. Optimization techniques such as linear or non-linear programming that minimize cost subject to reasonable constraints (e.g., labour availability, frost dates) can help improve profitability (Harrington, 1998).

ISSN 2229-5518

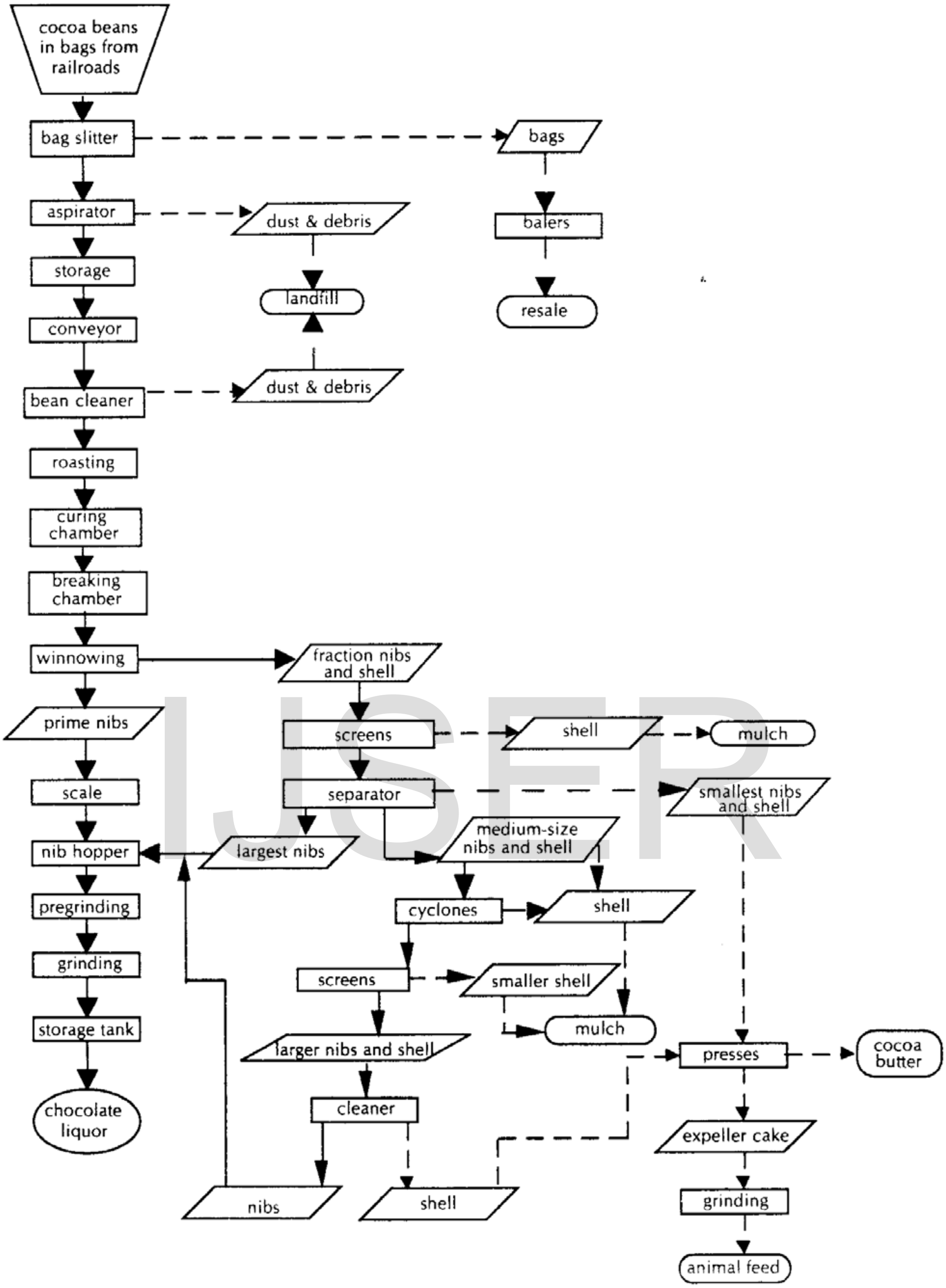


Fig.1 : Flow Chart of Cocoa Bean Processing Related
(http://www.cacaochocolade.nl/main.php?p)[accessed January 04, 2014]

ISSN 2229-5518

Cocoa Liquor Press Machine (Duyvis Press)

Duyvis Press (Case Study)

It was not until the year 1828 that a method was introduced for the separation of cocoa liquor into cocoa butter and cocoa cake. In that year the Dutchman Coenraad van Houten invented a process that enabled him to press a large part of the fat, or cocoa butter, from the semi-liquid cocoa liquor, for which he was granted a patent by King William I of the Netherlands (Duyvis, 2014)

The cocoa butter press has over the years developed into a highly advanced system, and with the advent of hydraulics, oil pressure could be increased to well over 500 bar. The diameter of the hydraulic ram was enlarged relative to that of the pots in order to achieve an even higher pressure on the liquor. The specific surface pressure on the liquor is to the pump generated oil pressure as the surface area of the hydraulic ram to the surface area of the pressing plate. The surface area of the ram is about twice the size of the pressing plate, which doubles the pressure on the liquor to about 1000 bar (Duyvis, 2014).

The cocoa press is a complex and extremely expensive piece of machinery which, depending on the type, can cost anything between 0.6 and 0.8 million Euro per piece including peripheral equipment.The liquid cocoa liquor is stored in large storage tanks where it is kept at a temperature of about 70^0C to ensure that the liquor remains liquid. From there the liquor is pumped to the liquor conditioning tanks mounted on each press, where the product is 'prepared' to achieve optimum conditions when it is pressed into cocoa butter and cocoa cake. The liquor is heated to the required temperature in the tank, while high-speed stirring gear ensures quick heat transfer and homogenization of the product as well as reducing the viscosity. This gives the product a relatively thin-fluid consistency, and improves its flow and pressing properties (Duyvis, 2014).

ISSN 2229-5518
Adequate maintenance and servicing is clearly essential for guaranteeing its long life. Maintenance of the press includes minor repairs such as regular replacement of filter screens and felt cords as well as cleaning of the press, but also an occasional major overhaul to ensure maximum technical performance. Checks should include testing the pressing temperature, the pressure of the hydraulic system (and possible leakage), the pneumatic system, the (optimum) closing of the press, as well as ultrasonic examination of the columns constantly exposed to heavy pressure.

Adequate maintenance and permanent checks are also required from a safety point of view. As pressing involves extremely high pressures, every company in the pressing industry has strict regulations that their staffs have to carefully observe. See plate 1 and figure 2 for the picture and diagram of cocoa press (Duyvis).

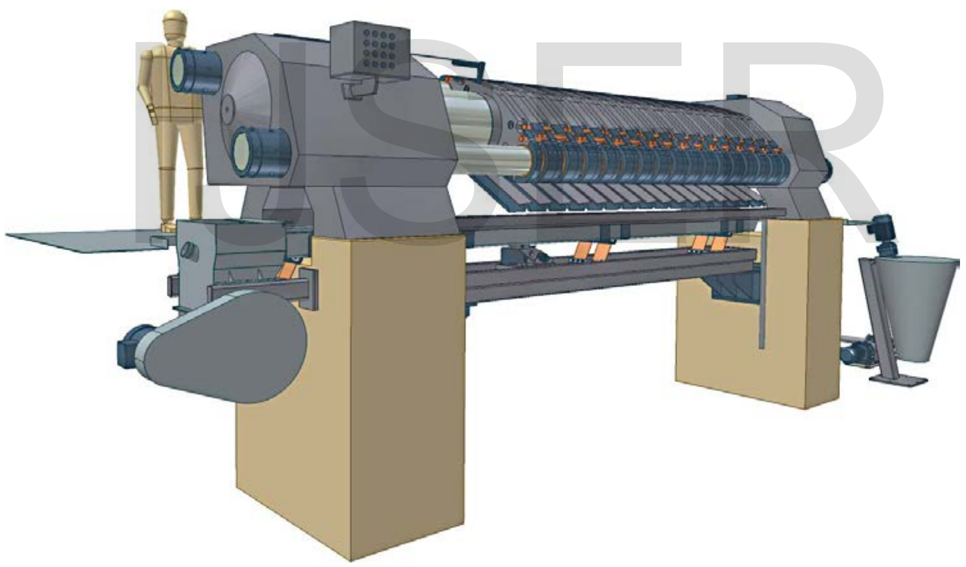


Plate 1: Cocoa Press with additional equipment

Source: Duyvis Press, 2014.

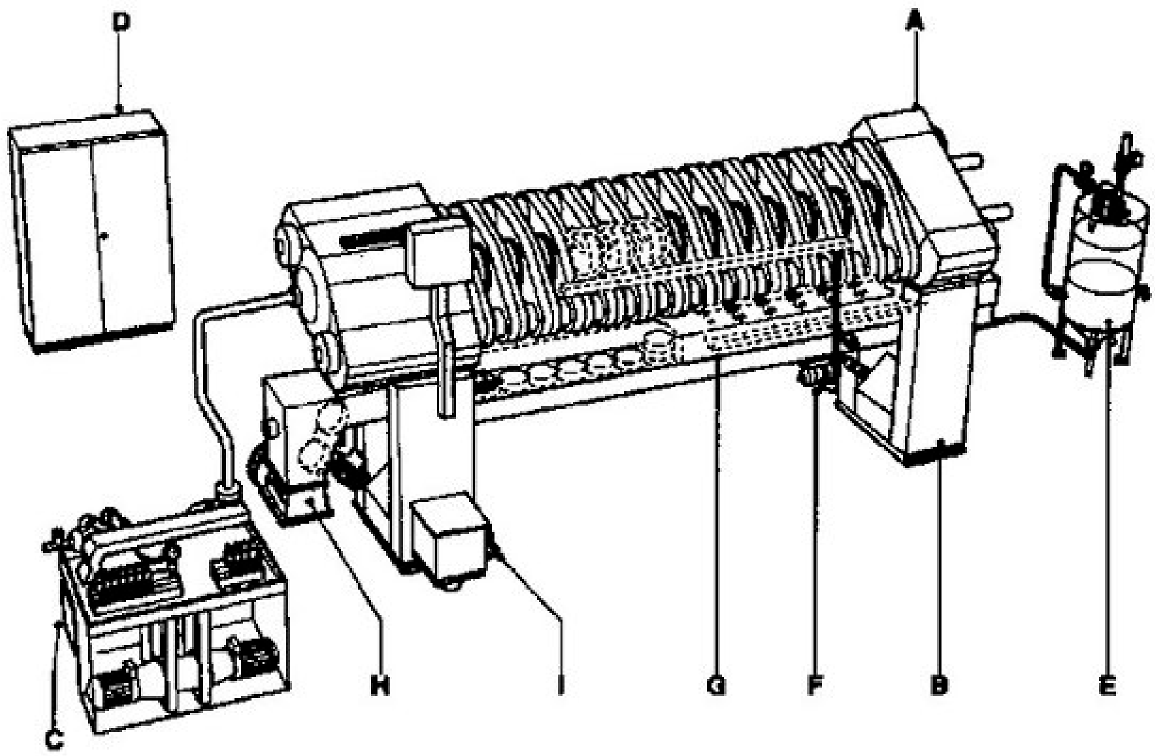


Figure 2: Cocoa press with auxiliary equipment(Duyvis)

Source: (http://www.cacaochocolade.nl/main.php?p)

The following are the cocoa pressers' components and their functions:

- **(A) Cocoa press:** This is the press machine (Duyvis) used to extract the cocoa butter from its liquor leaving behind its residue called cocoa cake.
- **(B) Support structures:** Structure designed according to the installation type, number of press installed as well as lay out and the forecast process flow. In general, the structures consist only in press bearing plinths and supports for conveyor, beaker, scale and pumps. The specific press structure extends to platform, ladders and handrails. All parts are in electro-welded steel submitted to anti-corrosion treatments and then powder coated.
- **(C) Hydraulic pump unit:** This is the heart of the pressing process.Hydraulic engineering and management logic make this hydraulic group series a cornerstone

about reliability, flexibility, power and energy saving with units able to adapt themselves to any kind of cocoa liquor to get the best pressing cycle performance.

(D) **Control panel:**This line control system is based on a general switchboard with SIEMENS PLC of S7300 family (different brands and configurations upon request).

The control system is based on a configuration with touch-screen operator panel on board for the equipment management and maintenance.

(E) **Conditioning tank:**The modern lines of squeezing high performance require an excellent homogenization of the product to ensure maximum efficiency. This is pre-mixing tanks to ensure perfect homogeneity and reduce the time of preparation of the cocoa mass for the presses.

(F) Liquor pump: Especially designed to be used on cocoa pressing lines to pump (transfer cocoa liquor through the piping(s). They are made of special steels and all the parts in contact with the product are treated and hardened to ensure a longer life to the seals.

(G) Cake conveyor:transport/convey the discharge cake from the press to the cake breaker to be kibbled. It also conveys the cake from the breaker to be pneumatically transported into a silo.

(H) Cake breaker: The purpose of the breaker is to crush cocoa cakes achieving controlled sized products to be conveyed to the silos, pneumatically or by other means. Structure, shaft, hammers, support bearings, as well as motorization are steel made and widely over dimensioned. The breaker is equipped with two types of cakes feeding hopper:

Independent hopper: in this case the breaker is sustained by proper supports.Carrying hopper to be coupled to the thrust conveyor TS Series achieving a unique module.

An electric isolator, connected to the motor and to a sensor located on the inspection port ensures a full safety during inspections. The standard configuration of the breaker is the “S” version where hammers configuration, matched to different grids, allows to set the wished size. Upon request the breaker can be delivered in the “R” version, too. Here the grid is formed of independent modules to achieve variable pitches and to vary the number of hammers. The milling axle in this configuration is concentric compared to the milling rotating axle. It is foreseen a flanged fastening to be connected to powder aspiration systems.

(I) **Butter pump:** Same as Liquor Pump

The technical characteristics of Duyvis press machine used as case study is as shown in table 1.

Table 1: Showing Duyvis press technical characteristics.

Model	**POV540/B2/14**
Number of pots	14
Weight	28500 kg
Machine Load	198 kg
Working Pressure	500 bars
Specific Pressure (kg/sq.cm)	825
Steam Pressure (kg/sq.cm)	4
Pneumatic Pressure (Bar)	6 - 8
Steam Consumption (kgH)	60
Air Consumption (dm^3/h)	56

Source: Study 2014

Some of the related works done so far in this area of study are hereby summarized in table 2.

Table 2: Some Authors and their Contributions

S/No.	Names/Years	Contributions
1.	Akinnuli et al. (2014)	Computer Aided Design for Cocoa Beans Processing Yield Prediction.
2.	Akinnuli et al. (2015)	Design concepts towards mechanization of cocoa beans winnowing process.
3.	Adzimah et al. (2010)	Design of cocoa pod splitting machine.
4.	Arai and Iwata, (1992)	Product Modeling system in conceptual design of mechanical products.
5.	Audu et al. (2014)	Development of a concentric cylinder locust dehuller.
6.	Awua, (2002)	Cocoa Processing and chocolate manufacture in Ghana.
7.	Bjarnemo et al. (1998)	Shortcomings of computer aided design systems in conceptual design.
8.	Bozzo et al. (1998)	Application of qualitative reasoning in Engineering.
9.	EEC (1973)	Directive 73/241 EEC by European parliament and the

		European Council relating to cocoa and chocolate products intended for human consumption.
10.	Faborode and Oladosun (1991)	Development of a cocoa pod processing machine.
11.	Harrington (1998)	Development of software tools for automation and acceleration of the engineering design process.
12.	http://www.worldcocoafoundation.org	Speciality crops for Pacific Island Agroforestry.
13.	Jurgen and Buhler (2009)	The manufacturing confectioner cocoa processing.
14.	Lipp and Anklam (1998)	Review of cocoa butter and alternative fats for use in chocolate.
15.	Whitefield (2005)	Making chocolates in the factory

Cocoa processing justification in Nigeria industries is premised on its bottleneck and delay which are paramount problems. This research tends to determine how effective a machine is performing compared with the laid down machines' effectiveness standard as well as determining the performance of the machine with the manufacturers set standards.

The objectives are to identify the area (s) of deficiency and control if for optimum effectiveness. Ability to achieve this well: increase the productivity of the plant, reduced down time period, maintain cost as well as bringing inventory cost to the barest minimum. The gap is yet to be filled as revealed in the literature review as at the commencement of this research in processing plant industry.

ISSN 2229-5518

Methodology

The methods to this research covered the parameters that is the strategic decisions used, their attributes, the model development and its manual application for results generation.

Nomenclature

The nomenclature to this research is as stated thus:

A = Availability of Machine

A_t = Actual Cycle time

A_p = Actual Processing time

B_l = Breakdown Losses

B_n = Number of Batches

B_t = Breakdown time (mins)

C_t = Cycle time (mins

Dt = Down time (mins)

d_t = Discharged time (mins)

Ic = Inspection Loss

L_t = Loading Time

L_m = Mass of liquor

M_l = Maintenance Loss

N_{hd} = Number of hours of operation/day

N_r = Net Operating Rate

O = Output per day

O_{mef} = Overall machine effectiveness

O_p = Operating Time (mins)

O_s = Operating Speed Rate

P_t = Processing time (mins)

P_{ef} = Performance Effectiveness of Machine

P_{fl} = Power Failure Loss

Q_d = Quantity defected

Q_o = Quality Output per day

Q_f = Quality of fat in cake

Q_{fb} = Quality of butter fatty acid

Q_{TPC} = Total plate count

Q_{TNTCP} = Too numerous to count plate

Q_r = Rate of Quality Products

R_t = Running time per day (mins)

S_l = Set up loss

St = Set up time (mins)

S_l = Stoppage Losses

T_p = Throughput per day

Q_o% = Percentage quality product

This nomenclature was used to develop the required models for determining the need parameter values.

Condition Acceptable to Ideal System

Model Development

(i) Determination of running time per day (R_t)

In this computation, the number of hours per day required is to be converted to minutes, then (R_t) is as shown in equation (1).

$$R_t = N_{hd} \text{ x } 60 \quad (1)$$

(ii) Determination of loading time per day (L_t)

To determine the loading time, the down time in minutes is deducted from the running time per day as shown in equation (2)

$$L_t = R_t - D_t \qquad (2)$$

(iii) Determination of Stoppage Losses per day (S_l)

These are summation of the breakdown, set up loss, power failure, maintenance and inspection losses. This formed equation 3.

$$S_l = \sum (B_l, S_l, P_{fl}, M_l, I_c) \qquad (3)$$

(iv) Determination of Operating time per day (O_p)

To determine the operating time per day, the loading time in minutes is deducted from the stoppage loss as seen in equation (4)

$$O_p = Lt - S_l \qquad (4)$$

(v) Determination of rate of Quality Products (Q_r)

To determine the rate of quality products, this is obtained by deducting the throughput per day from quality output per day divided by running time per day (minutes) as shown in equation (5)

$$Q_r = (T_p - Q_0)/R_t \qquad (5)$$

(vi) Determination of Actual Processing Time

The actual processing time, is the product of output per day and actual cycle time as shown in equation (6)

$$A_p = P_t \; x \; B_n \qquad (6)$$

(vii) Determination of Availability of the Machine (A)

Availability of the machine is the operating time divided by loading time as shown in equation (7).

$$A = R_t / O_p \quad (7)$$

(viii) Determination of Operating speed rate of machine (O_s)

Operating speed rate of the machine is inspection loss divided by actual cycle time as shown in equation (8).

$$O_s = (C_A / C_i) x 100\% \quad (8)$$

(ix) Determination of Net Operating Rate (N_r)

To determine the net operating rate, this is actual processing time divided by output per day as shown in equation (9)

$$N_r = A_p / O_p \quad (9)$$

(x) Determination of Machines Performance Efficiency (P_{eff})

Machines performance efficiency is operating speed rate multiplied by number of hours of operation per day as shown in equation (10).

$$P_{eff} = O_s \; x \; N_r \quad (10)$$

(xi) Determination of Overall Machine Effectives O_{mef}

The overall machine effectives, is the product of availability of the machine, machine performance efficiency and rate of quality of products as shown in equation (11).

$$O_{mef} = A \; x \; P_{eff} \; x \; Q_r \quad (11)$$

Conditions Acceptable to Ideal System

Availability (A> 90%) = $(A)_I$

Performance Efficiency (P_{ef}) > 95% = $(P_{ef})_I$

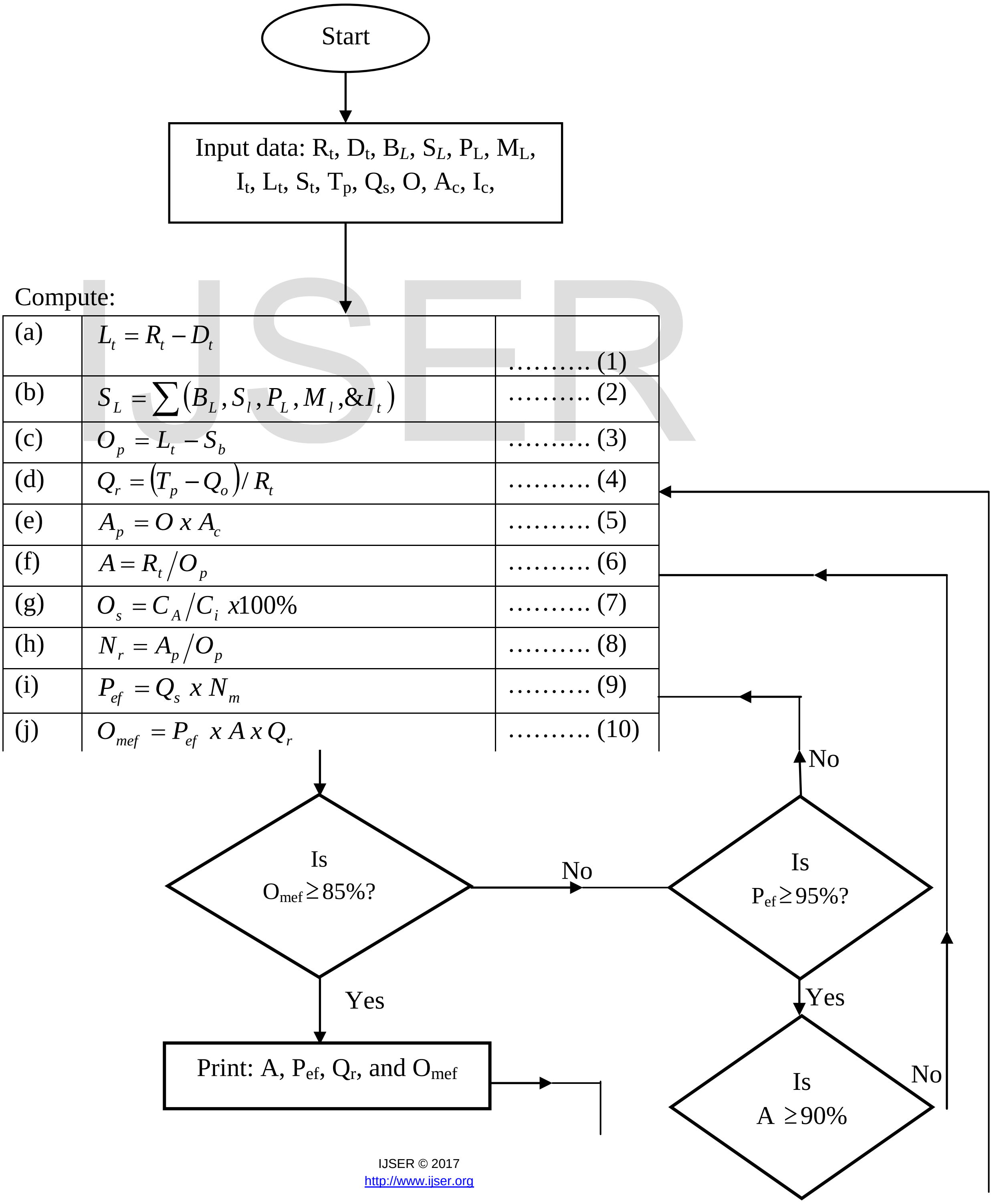
Rate of quality products (Q_r)> 99% $(Q_r)_I$

$\therefore$ Ideal overall equipment effectiveness should be:

Ioeff $0.90 \text{ x } 0.95 \text{ x } 0.99 = 0.84643 \cong 85$

Compare O_{mef} with I_{off} if (i) $O_{mef} < I_{off}$ = Not Effective.

(ii) $O_{mef} \geq I_{off}$ = Effective.



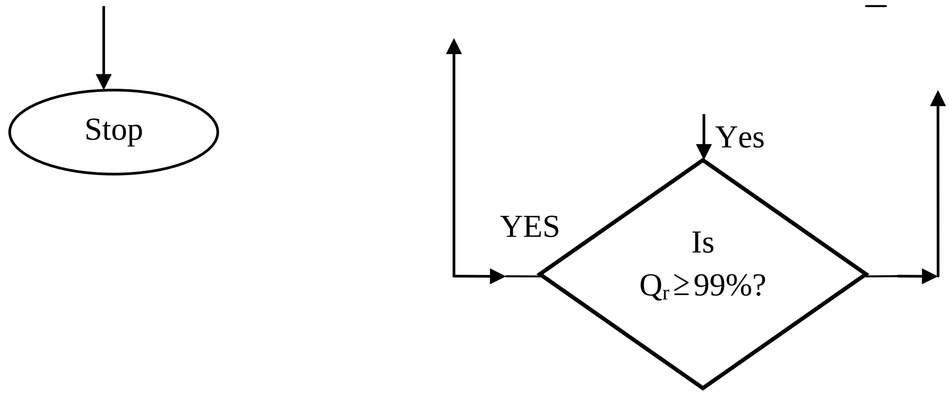


Fig. 4: Developed Flow Chart for the Models Required

The developed model was applied to this case study to determine it's effectiveness. The summary of the results are shown in table 3 using data collected from the machine from Olam Cocoa Processing Industry I Km 5 ilesha Owo express way, Akure, Ondo State, Nigeria.

Table 3: Summary of the Manual Computation Results Using the Model Developed to Ascertain the Effectiveness of Duyvis Press.

S/No.	Parameters	Model Used (Equation)	Model Number	Results

1.	Running Time(R_t)	$R_t = N_{hd}$ x 60	(1)	1375 mins/day
2.	Loading Time per day (L_t)	$L_t=R_t- D_t$	(2)	90 mins
3.	Stoppage Losses per day (S_{tL})	$S_{tL}= (B_I,S_t,P_{fI}, M_{I,} I_c)$	(3)	1440 mins/day
4.	Operating time per day (O_p)	$O_p=L_t-S_{tL}$	(4)	57 mins/day
5.	Rate of Quality of Products (Q_t)	$Q_t= (T_p- Q_o)/R_t$	(5)	99.5 %
6.	Actual Processing Time (A_p)	$A_p= P_t$x B_n	(6)	21 Hrs (504mins/day)
7.	Machine Availability (A)	$A = R_t/O_p$	(7)	0.96 or 96 %
8.	Operating Speed of Machine (O_s)	$O_s= (C_A/C_i)$	(8)	100 % = 1
9.	Net Operating Rate (N_r)	$N_r = A_p/O_p$	(9)	0.88 = 88 %
10.	Machine Efficiency (P_{eff})	$P_{eff}= O_s$x N_r	(10)	0.88 = 88 %
11.	Overall Machine Effectiveness (O_{meff})	O_{meff} = A x P_{eff}xQ_t	(11)	0.84 = 84 %

Results and Discussions

The models required for determining the effectiveness and control the performance of Duyvis press has been developed. The identified strategic decisions with their attributes were found acceptable for the necessary computations (Martand, 2006). The ideal overall machine minimum acceptable effectiveness recommended 85 % performance despite the machine availability is more than the 90 % required. The quality of product is also good as expected within the specified time.

(i) The machine effectiveness is below the minimum recommendation of 85 %.
(ii) Machine availability is 96 % which is 6 % above the 90 % recommended value.

The efficiency of the machine being 88 % is less than recommended value of 95 % by 7 %.

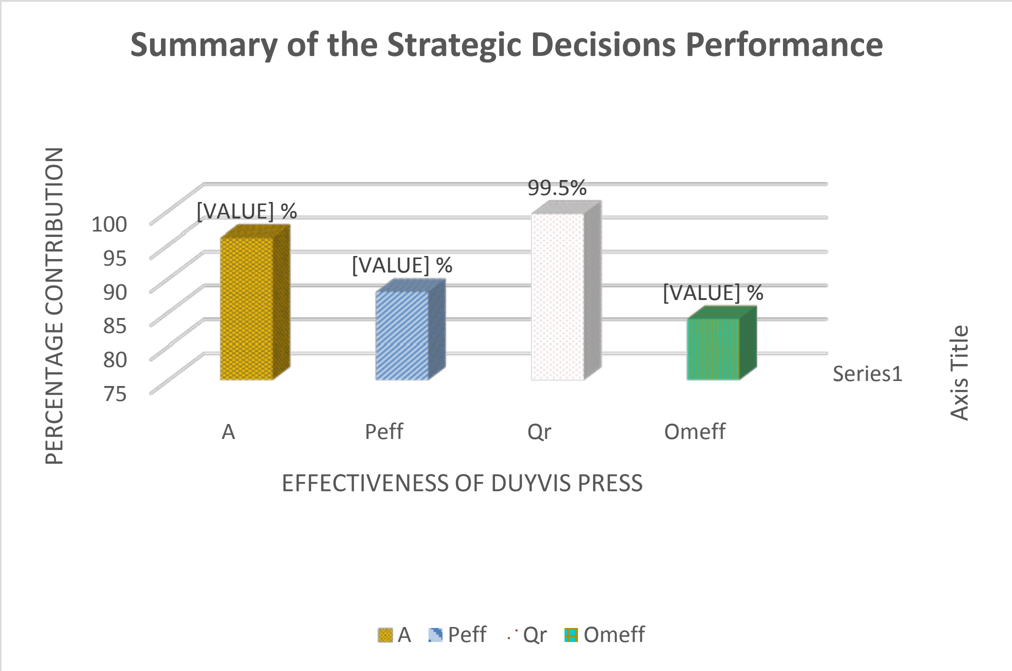


Fig. 5: Summary of the Strategic Decisions Performance

Where A= Availability

P_{eff}= Machine Efficiency

Q_r= Rate of Quality Products

O_{meff}=Overall Machine Effectiveness

To improve the overall effectiveness of this Duyvis press machine, it's efficiency must be improved to be greater than 88 % of its present value putting into consideration this two major attributes: operating speed of the machine and net operating rate.

All the results may work for another model of machines with higher down time, higher capacity by volume, but for this particular press machine in question, the average stoppage time/day needs to be reviewed for improved overall machine effectiveness.

Consequently, pressing time should be reduced if it will not affect the cake fat content.

Average breakdown losses, must be reduced to the barest minimum, power failure time if possible should be reviewed in such a way that it will not occur every day, may be twice in a week.

Time taken for maintenance should also be reviewed and better maintenance plan should be put in place because time used for maintenance takes most of the stoppage losses time/per day. If preventive maintenance plan is in place, it will go a long way in preventing excess time used on breakdown.

The parameter that needs to be worked upon are the loading time, processing time and discharge time. These are to be reduced so that the output can be improved, that is the number of batches will increase.

Conclusions

An empirical model has been developed as proposed. The strategic decisions selected for effective performance of the machine determination were good for decision making. The case study used in this study "Duyvis Liquor press" was found to have daily running time of 1375 mins/day; loading time of 90 mins; operating time 1440 min/day; stoppage losses of 57 mins/day; rate of quality products 99.5 %; actual processing time of 504 mins/day; (21:00 Hrs); machine availability of 96 %; net operating rate 88 % while overall machine effectiveness is 84 %. This is below the recommended standard of 85 %. This is as a result that one of the strategic decisions "efficiency" is below the minimum acceptable limit. Therefore, operating speed of this machine (O_s) as well as it's net operating rate (N_r) are to be improved in order to increase the machine efficiency (P_{eff}).

When these methods were technically followed, the set objectives will surely be achieved as well as the aim of developing a software capable of evaluating agricultural equipment/machinery performance.

REFERENCES

Adzimah S.K., Baker C.G.J. and Asiam E.K. (2010). "Design of Cocoa pod Splitting machine" *(Research Journals of Applied Science Engineering Technology, 2(4): 622-634.*

Akinnuli, B.O., Ayodeji, S.P. Omeiza, A.J. (2014). Computer Aided Design for Cocoa Beans Processing Yield Prediction: International Journal of Applies Science and technology, vol (4), No. 5 USA. ISSN 2221 – 0997 pp82-91.

Akinnuli, B.O., Bekunmi, O.S. and Osueke, C.O. (2015): Design Concept towards Cocoa

Winnowing Mechanization for Nibs Production in Manufacturing Industries. British Journal of Applied Science and Technology, Science domain International, UK 161 (8), Issue 01, Pp 35 – 45 ISSN 2231 – 0843.

Alias/Wavefront – http://www.aw.sgi.com/design/products.

Arai, E. and Iwata, K., (1992). "Product Modeling System in Conceptual Design of Mechanical Products", Robotics & Computer-Integrated Manufacturing, Vol. 9, No. 4-5, Aug-Oct, pp. 327-334.

Audu, I., Oloso A.O.and Umar, B. (2004). "Development of a concentric cylinder locust Dehuller". CIGR-Ejournal PM 04 003, Vol: 6.Pp28-32.

Awua, P.K. (2002). "Cocoa processing and chocolate manufacture in Ghana". Essex. David Jamieson and Associates Press Inc.

Biren Prasad, (1996). "Concurrent Engineering Fundamentals – Integrated Product and Process Organisation", Prentice Hall.

Bjarnemo, R., Burman, A., and Anker, J.C., (1995). "Shortcomings of Computer Aided Design Systems in Conceptual Design", Current Topics in Computational Mechanics, AmericanSociety of Mechanical Engineers, Pressure Vessels and Piping Division (Publication) PVP, Vol. 305, pp. 227-232.

Bozzo, L.M., Barbat, A., and Torres, L., (1998) "Application of Qualitative Reasoning in Engineering", Applied Artificial Intelligence, Vol. 12, No. 1, Jan-Feb,pp. 29-48.

Burman, A. and Anker, J.C., (1994). "A Concept for a Finite Element Based Design Tool", Advanced Computer Applications American Society of Mechanical Engineers, Pressure Vessels and Piping Division (Publication) PVP, Vol. 274, ASME, New York, pp. 103-112.

EEC (1973). Directive 73/241/EEC by European Parliament and the European Council relating to cocoa and chocolate products intended for human consumption. OfficialJournal of the European Communities L 228 of 16/08/1973, pp. 0023-0035.

Faborode, M.O. and Oladosun, G.A. (1991). "Development of a cocoa pod processing Machine". Nigerian Eng.,26(4): pp 26-31.http://www.cacaochocolade.nl/main.php?phttp://www.dmoz.org/Science/Biology/Flora_and_Fauna/Plantae/Magnoliophyta/Magnoli opsida/Sterculiaceae/Theobroma. Accessed January 09, 2014.

Harrington, B.W., (1998). Development of Software Tools for Automation and Acceleration of the Enginering Design Process, IEEE Aerospace Applications Conference Proceedings, Vol. 4, pp. 265-275.

http://www.worldcocoafoundation.orgSpecialty Crops for Pacific Island Agroforestry (http://agroforestry.net/scps) 23.

Hsu, W. and Woon, I.M.Y, (1998). "Current Research in the Conceptual Design of Mechanical Products", Computer-Aided Design, Vol. 30, No. 5 Apr, pp. 377-389

Jurgen, F. and Buhler, B. (2009). "The manufacturing confectioner Cocoa Processing—Cleaning through Roasting".

Lectra systemes- http://www.lectra.com

Lipp, M. and Anklam, E. (1998). "Review of cocoa butter and alternative fats for use inChocolate- Part A". Compositional data. Food Chem, 62: pp73-79.

Lipson, H. and Shpitalni, M., (1995)."New Interface for Conceptual Design Based on Object Reconstruction From a Single Freehand Sketch, Cirp Annals", Vol. 44, No. 1, pp. 133-136.

Lorenzi, H., Sartori, S.F., Bacher, L.B. and Lacera, M. (2006). "Brazilian fruits and cultivated exotics (for consuming natura). Instituto Plantarum de Estudos da Flora". São Paulo, Brazil.

Martand, T. (2006). Industrial Engineering and Production Management, 2nd Edition, S.Chard and company Ltd., Ram Nagar, New Delhi – 110055 ISBN: 81 – 219 – 1773 – 5 Pp 558 – 562.

Nickless, H. (1996). "Cocoa butter quality". In: Selamat J, Lian BC, Lai TK,

Opeke, L.K., (1987). "Tropical Tree Crops". John and Sons, Clichester, pp: 108-119.

Open Directory page for cacao:The Chocolate Life: http://www.thechocolatelife.com

Open Directory page for cacao:http://www.dmoz.org/Science/Biology/Flora_and_Fauna/Plantae/Magnoliophyta/Magnoliopsida/Sterculiaceae/Theobroma.

Paraform system – http://www.geomatic.com

Pontillon J (1998). Le beurre de cacao et les matières grasses en chocolaterie. In :Pontillon J (ed) Cacao, chocolat, production, utilisation, caractéristiques (p. 326). Techniques et documentation,Lavoisier, Paris, pp. 257-269.

Rembold, U. Nnaji B.O. and Storr, A. (1993). "Computer Integrated Manufacturing and Engineering" Addison-Welsley.

Roy L. Wysack, (1985) "Effective Computer Aided Design Mangement – A Manger's Guide", Computer Aided Design / Computer Aided Manufacturing Publishing.

Selamat, J. Hamid, M.A., Mohamed, S., Man, C.Y. (1996). "Physical and chemical characteristics of Malaysian cocoa butter".

Sensable system – http://www.sensable.com

The Computer Aided Design Report, Computer Aided Design/Computer Aided Manufacturing (1999). Publishing Inc., Vol.19, No 2,.

The Select-IT project, http://www.select-it.org.uk

Unigraphics system, -http://www.ugsolutions.com

Van Dijk, C.G.C, (1995). "New Insights in Computer-Aided Conceptual Design", Design Studies, Vol. 16, No. 1, January, pp. 62-80.

Vejesit, A. and Salokhe, V. (2004). "Studies on machine crop parameters of an axial flow thresher for threshing soy bean". CIGR-Ejournal, Vol: 6.

Whitefield, R. (2005). "Making chocolates in the factory". Kenedy's Publications Ltd, London.

Wood, G.A.R., and Lass, R.A. (1985). Cocoa. Longman, London & New York.*Research Journal of Applied Science Engineering Technology, 2(4): 622-634, 2010*

World Cocoa Foundation scientific research and web site library: http://www.worldcocoafoundation.org

www.jvalentino@qcc.cuny.edu

Zeid, H. (1990) "Computer Aided Design / Computer Aided Manufacturing Theory and Practice", McGraw Hill.

APPENDIX 1

Output of Three Different Duyvis Presses

DATE	PRESS 1	Output (kg)	PRESS 2	Output (kg)	PRESS 3	Output (kg)	Total Pressed	Output (kg)
09/01/2014	43	8600	0	0	47	9400	90	18000

ISSN 2229-5518

09/02/2014	72	14400	0	0	70	14000	142	28400
09/03/2014	52	10400	0	0	53	10600	105	21000
09/04/2014	67	13400	0	0	66	13200	133	26600
09/05/2014	64	12800	0	0	64	12800	128	25600
09/06/2014	82	16400	0	0	87	17400	169	33800
09/07/2014	75	15000	0	0	77	15400	152	30400
09/08/2014	71	14200	0	0	72	14400	143	28600
09/09/2014	67	13400	0	0	68	13600	135	27000
09/10/2014	66	13200	0	0	64	12800	130	26000
09/11/2014	82	16400	0	0	83	16600	165	33000
09/12/2014	86	17200	0	0	83	16600	169	33800
13/9/2015	75	15000	0	0	76	15200	151	30200
14/9/2015	76	15200	0	0	77	15400	153	30600
15/9/2014	82	16400	0	0	81	16200	163	32600
16/9/2014	66	13200	0	0	74	14800	140	28000
17/9/2015	78	15600	0	0	78	15600	156	31200
18/9/2015	50	10000	0	0	54	10800	104	20800
19/9/2015	72	14400	0	0	77	15400	149	29800
20/9/2016	74	14800	0	0	71	14200	145	29000
21/9/2016	43	8600	0	0	54	10800	97	19400
22/9/2017	73	14600	32	6400	74	14800	179	35800
23/9/2018	64	12800	75	15000	82	16400	221	44200
24/9/2019	80	16000	57	11400	77	15400	214	42800
25/8/2014	76	15200	52	10400	69	13800	197	39400
26/8/2014	61	12200	62	12400	42	8400	165	33000
27/8/2014	32	6400	70	14000	66	13200	168	33600
28/8/2014	65	13000	34	6800	59	11800	158	31600
29/8/2014	80	16000	0	0	83	16600	163	32600
30/8/2014	90	18000	0	0	90	18000	180	36000
31/8/2014	81	16200	0	0	81	16200	162	32400
TOTAL	**2145**	**420400**	**382**	**76400**	**2152**	**430400**	**4636**	**927200**